US 20060054433A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2006/0054433 A1**

Hadden et al. (43) **Pub. Date: Mar. 16, 2006**

(54) **CRYOGENIC FLUID MASS DAMPER USING CHARGED PARTICULATES FOR STICTION-FREE DAMPING**

(76) Inventors: **Steve L. Hadden**, Peoria, AZ (US); **Thomas R. Kreider**, Mesa, AZ (US); **Mason A. Peck**, Ithaca, NY (US)

Correspondence Address:
HONEYWELL INTERNATIONAL INC.
101 COLUMBIA ROAD
P O BOX 2245
MORRISTOWN, NJ 07962-2245 (US)

(21) Appl. No.: **10/942,289**

(22) Filed: **Sep. 15, 2004**

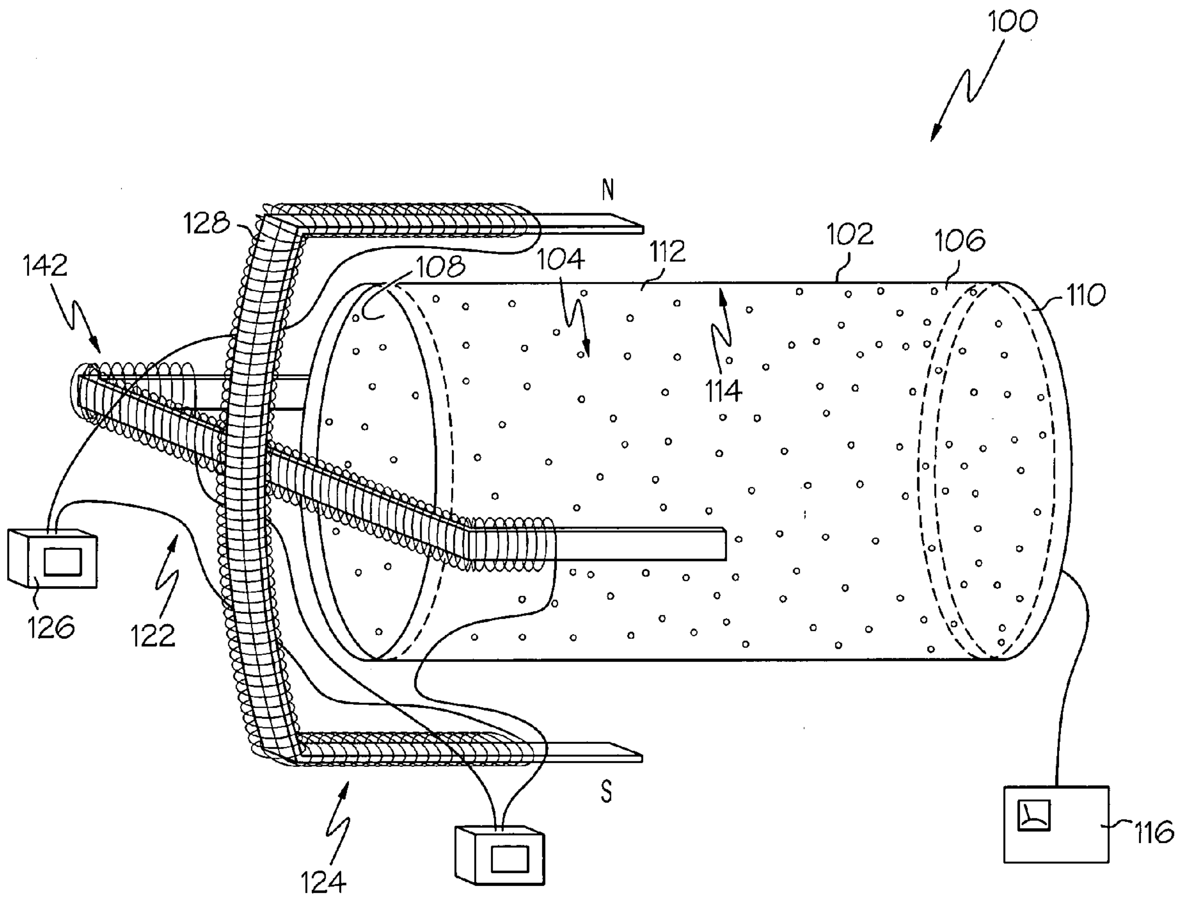
Publication Classification

(51) **Int. Cl.**
F16F 9/06 (2006.01)

(52) **U.S. Cl.** **188/269**

(57) **ABSTRACT**

A mass damper is provided for damping a mass. The mass damper includes a housing configured to couple to the mass and a plurality of electrostatically charged particles disposed within the housing, where the particles do not clump to one another or stick to the housing.



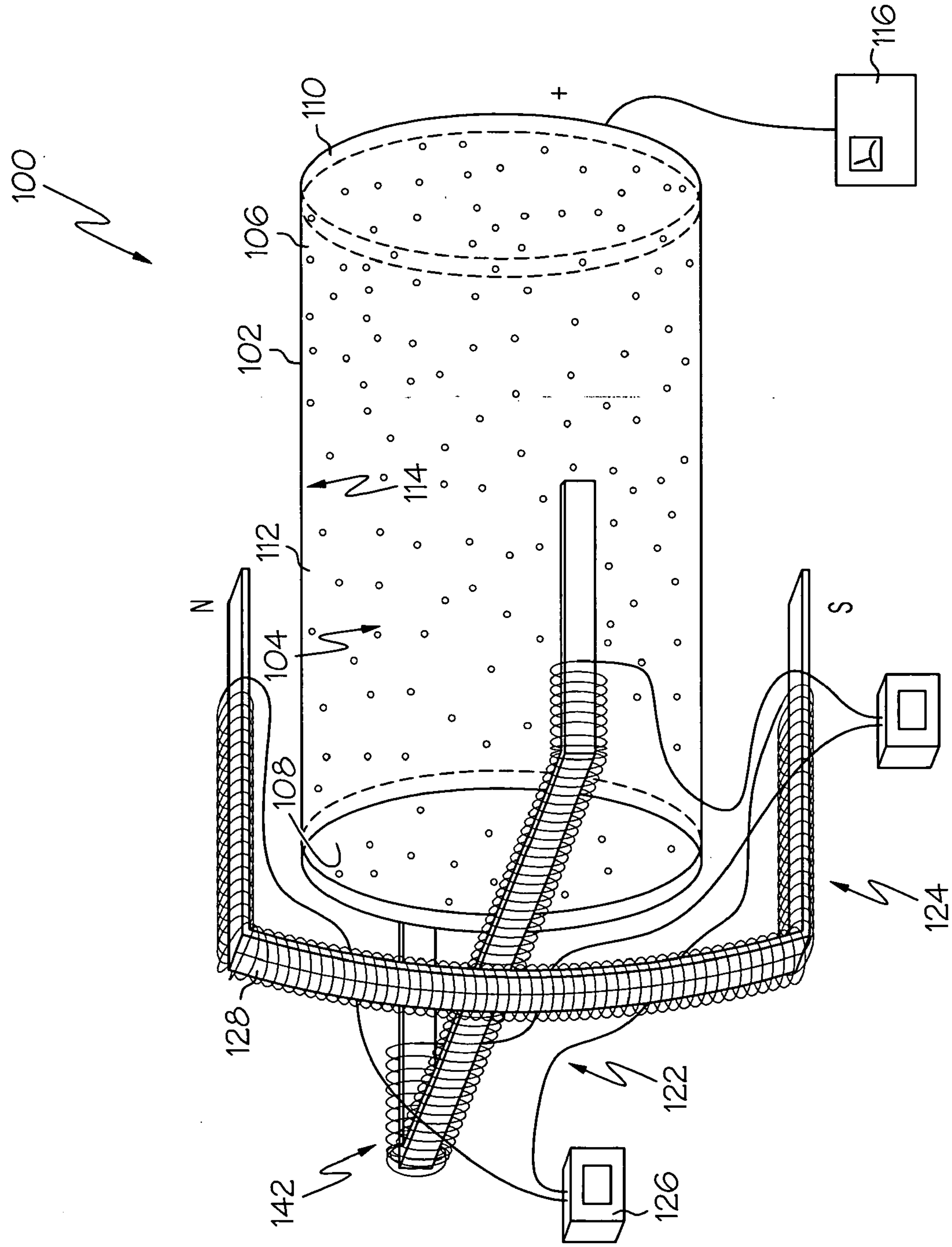


FIG. 1

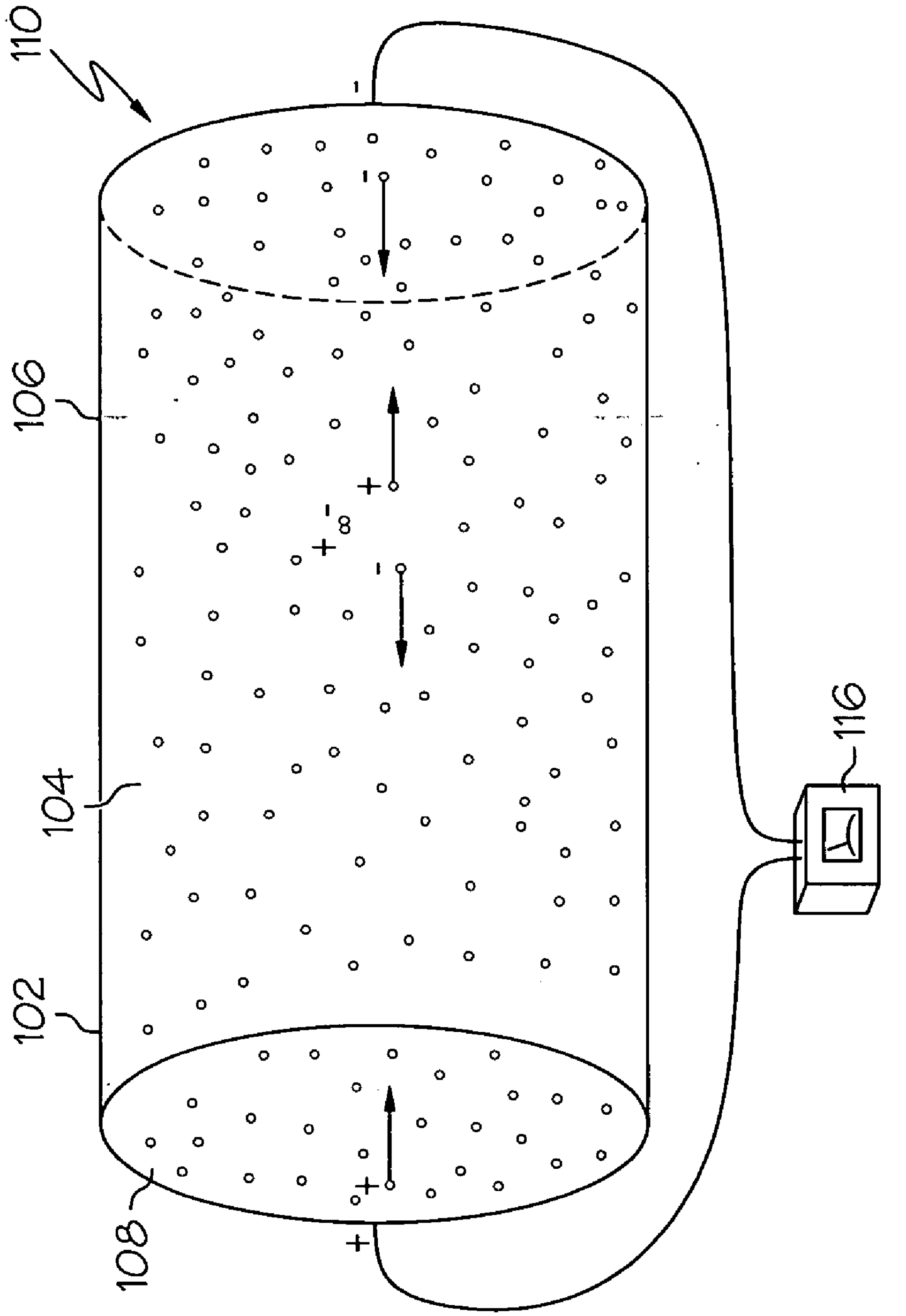


FIG. 2

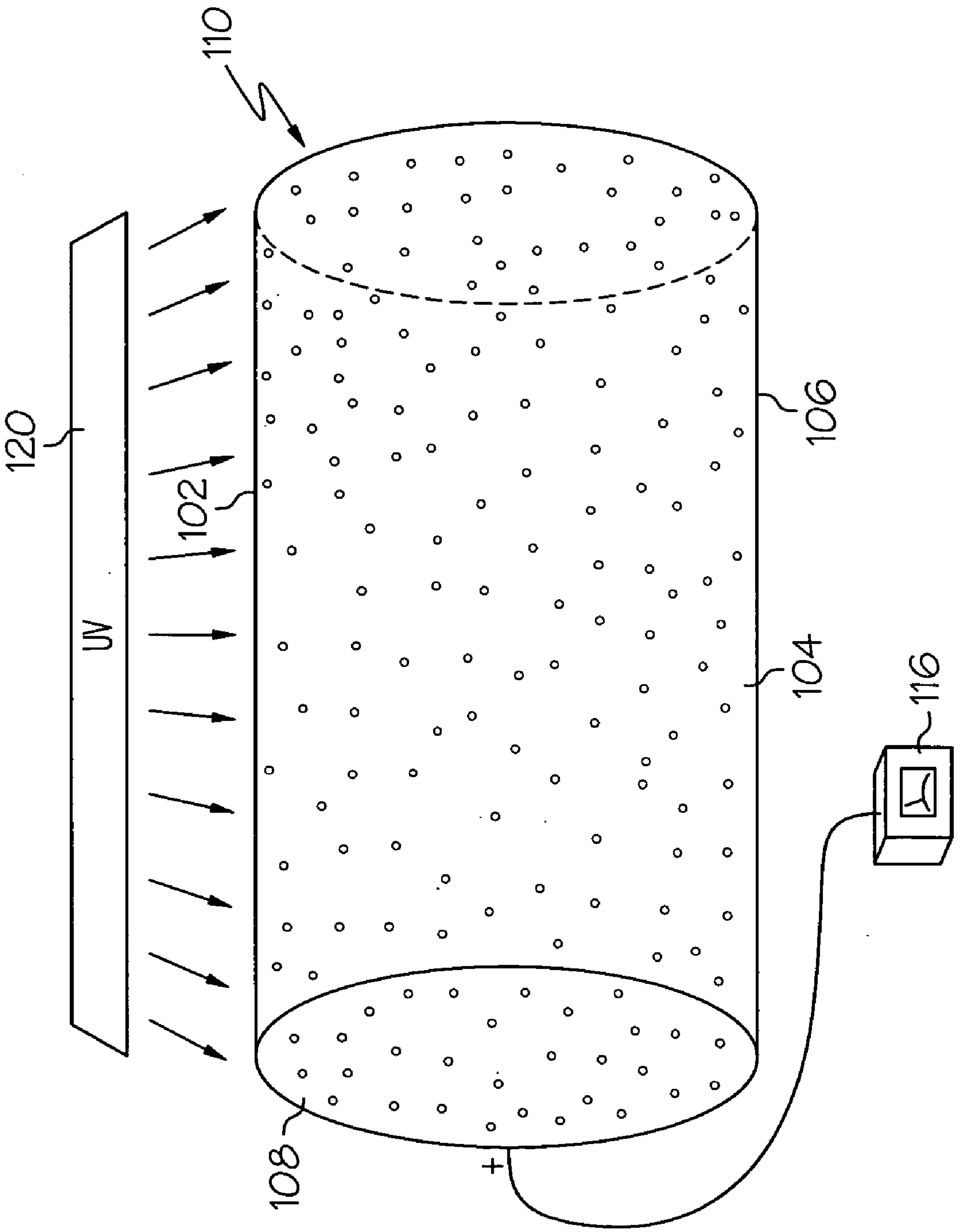


FIG. 3

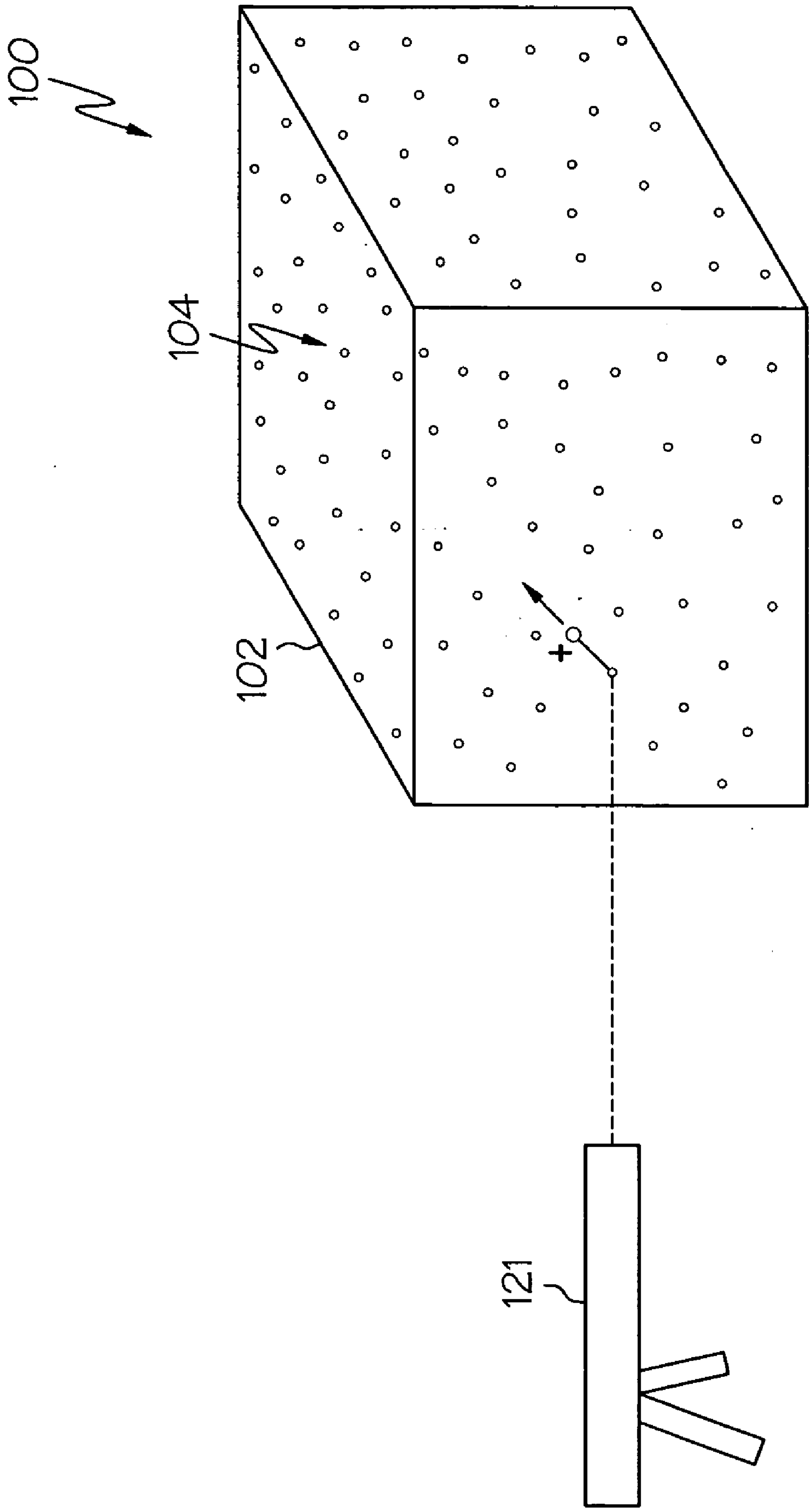


FIG. 4

CRYOGENIC FLUID MASS DAMPER USING CHARGED PARTICULATES FOR STICTION-FREE DAMPING

FIELD OF THE INVENTION

[0001] The present invention generally relates to vibration damping and isolation, and more particularly relates to an apparatus that uses charged particulates, without liquid media, to dampen vibration.

BACKGROUND OF THE INVENTION

[0002] A precision pointing system carrying a sensor, such as a telescope as its payload, may be susceptible to disturbances that produce structural vibrations and, consequently, pointing errors. Such vibrations may be attributed to mechanical components or assemblies, such as reaction wheel assemblies that are used as actuators in the precision pointing system. For the most part, because these systems tend not to have significant, inherent damping, these structural vibrations may degrade system performance and even cause structural fatigue over time. Therefore, an efficient means of damping the system may be needed.

[0003] Typically, to minimize performance degradation caused by vibrations, a passive-mass damping and isolation system is used for damping the structure and isolating the payload carried by a precision isolation system. One type of passive mass damping and isolation system is a fluid damper. Fluid dampers operate by displacing a viscous fluid from one fluid reservoir to another fluid reservoir through a restrictive passage. Shearing of the viscous fluid as it flows through the restrictive passage provides a force that is proportional to velocity, i.e. a damping force.

[0004] In these types of dampers, the viscous fluid is typically water, oil, or any one of numerous other fluid substances that are not in the gas, plasma, or solid phase. Although these fluids may be used in damping mechanisms that operate in environments where the range of temperature and pressure correspond to the fluid's liquid phase, they are inappropriate for environments outside this range. For instance, in the aerospace context where damping mechanisms may be exposed to temperatures that approach absolute zero, most of the fluids used in fluid dampers have low viscosity and/or may be a solid rather than a fluid.

[0005] In other types of dampers, such as pneumatic fluid mass dampers, gases are used. Pneumatic fluid mass dampers operate by varying pressure, temperature, and gas viscosity. However, in extreme low temperatures, such as 0° Kelvin, gas-to-liquid phase changes may occur. Such changes are generally undesirable because when the gas changes into a liquid, the resulting volume of liquid and gas may not adequately absorb the system vibration and instead may begin to vibrate itself.

[0006] One approach to addressing the above-mentioned drawbacks was developed by some of the inventors of the present invention. The prior approach, disclosed in U.S. patent application Ser. No. 10/728,225 filed Dec. 3, 2003 entitled "Apparatus for Damping Vibration Using Macro Particulates," and assigned to the assignee of the instant application, provides a mass damping system including a container within which a plurality of particulates is disposed. Although this prior approach addresses at least some of the above-noted drawbacks, it too presents certain drawbacks. In particular, although particulates may be insusceptible to phase change at extreme low temperatures, they may clump together into solids and vibrate with the mass instead of damping the mass.

[0007] Accordingly, there is a need for an improved vibration damping system whose constituents do not clump and that can be used in most temperature ranges, particularly in extreme cryogenic temperature environments or extreme heat environments. Furthermore, other desirable features and characteristics of the present invention will become apparent from the subsequent detailed description of the invention and the appended claims, taken in conjunction with the accompanying drawings and this background of the invention.

BRIEF SUMMARY OF THE INVENTION

[0008] A mass damper is provided for damping a mass. The mass damper includes an electrostatically charged housing configured to couple to the mass and a plurality of electrostatically charged particles disposed within the housing, each particle electrostatically charged with like polarity to that of the electrostatically charged housing.

[0009] Another embodiment of the mass damper includes a housing, a plurality of particles, and a power source. The housing is configured to couple to the mass. The plurality of particles is disposed within the housing. The power source is coupled to the housing and configured to supply an electric potential thereto and electrostatically charge the housing, whereby when one of the particles of the plurality of particles contacts the housing, the particle is electrostatically charged.

[0010] Yet another embodiment of the mass damper includes a housing, a plurality of particles, a conductive element and a power source. The housing is configured to couple to the mass. The plurality of particles is disposed within the housing. The conductive element is disposed within the plurality of particles. The power source is coupled to the housing and configured to supply an electric potential to the conductive element and electrostatically charge the conductive element, whereby the particle is electrostatically charged when one of the particles of the plurality of particles contacts the conductive element.

[0011] Still yet another embodiment of the invention includes a housing, a plurality of particles, and a high-energy light source. The housing comprises negatively charged non-conductive material and is configured to couple to the mass. The plurality of particles is disposed within the housing. The high-energy light source is aimed at the plurality of particles and configured to direct high-energy photons toward at least one particle of the plurality of particles to thereby charge the particle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The present invention will hereinafter be described in conjunction with the following drawing figures, wherein like numerals denote like elements, and

[0013] **FIG. 1** is a schematic, cross sectional view of an exemplary mass damper;

[0014] **FIG. 2** is a schematic, cross sectional view of another exemplary mass damper;

[0015] **FIG. 3** is a schematic, cross sectional view of another exemplary mass damper;

[0016] **FIG. 4** is a schematic, cross sectional view of yet another exemplary mass damper; and

[0017] **FIG. 5** is a schematic, cross sectional view of still yet another exemplary mass damper.

DETAILED DESCRIPTION OF THE INVENTION

[0018] The following detailed description of the invention is merely exemplary in nature and is not intended to limit the invention or the application and uses of the invention. Furthermore, there is no intention to be bound by any theory presented in the preceding background of the invention or the following detailed description of the invention.

[0019] **FIG. 1** illustrates a mass damping system **100** according to an exemplary embodiment of the invention. The system **100** includes a housing **102**, a plurality of particles **104**, and an electrostatic charge supply **116**. The housing **102** has a cylindrical sidewall **106** and two end walls **108, 110** coupled to each of the ends of the cylindrical sidewall **106**. The walls **106, 108, 110** include an interior surface **114** that defines a chamber **112** within the housing **102**. Although the housing **102** is described herein as being cylindrical, it will be appreciated by those with skill that any one of a number of different shapes may be employed, such as for example, rectangular, prism-shaped, or square.

[0020] The housing **102** may be constructed of any one of numerous types of materials that are either conductive or non-conductive (insulating). Conductive materials include, but are not limited to metallic materials, such as copper, aluminum, iron, and steel, or graphite, and insulating materials include but are not limited to glass, rubber, and ceramic. In either case, as will be discussed in more detail further below, an electrostatic charge is maintained on the housing **102**.

[0021] The plurality of particles **104** are disposed within the housing chamber **112** and are used to absorb vibration from a vibrating mass. Preferably, the plurality of particles **104** has properties that allow it to simulate a homogenous fluid with inherent shear. Similar to the housing **102**, an electrostatic charge is also maintained on each of the plurality of particles **104**. The electrostatic charge on the particles **104** is of the same polarity as that on the housing **102**. The like electrostatic charge on the housing **102** and the particles **104** cause the housing **102** and particles **104** to repel one another, and the individual particles **104** to repel one another. As a result, particle clumping does not occur and the particles **104** simulate a fluid.

[0022] The electrostatic charges on the housing **102** and the particles **104** may be induced in any one of numerous manners. For example, electricity may be introduced into the system **100** to cause the system components to have like electrostatic charges. In other examples, light or nuclear energy may be introduced into the system **100**. The method by which electrostatic charges are induced largely depends upon the materials from which the housing **102** and the plurality of particles comprise. Examples of various charging methods will now be described in detail below. It will be appreciated that system **100** components can have either a positive or negative charge, and although the components are described below and/or illustrated as having a positive charge, they may alternatively have a negative charge.

[0023] Returning to **FIG. 1**, in the exemplary embodiment depicted therein both the housing **102** and plurality of particles **104** are made of conductive material, and the electrostatic charge supply **116** is an electric power supply. The power supply **116** is coupled to the housing **102** and is configured to create a deficiency of electrons in the housing **102** so that it becomes positively charged. Preferably, the power supply **116** is configured to carry the electrons away from the system **100**. Thus, when one of the particles **104** contacts the housing **102**, it too becomes positively charged, as it loses an electron to the positively-charged housing **102**. Once the particle **104** becomes positively charged, it repels the positively-charged housing **102**. Over time, more and more of the particles **104** contact the housing **102** and become positively charged, until substantially all of the particles **104** have like electrostatic charges. As a result, the particles **104** repel one another and the individual particles **104** do not clump. Additionally, the particles **104** do not adhere to the housing **102**.

[0024] In another exemplary embodiment, such as depicted in **FIG. 2**, the housing cylindrical sidewall **106** is constructed of an insulating material, the end walls **108, 110** are made of a conducting material, and the power supply **116** is coupled to both end walls **108, 110**. Those with skill in the art will appreciate that alternatively separate power supplies may be coupled to each of the end walls **108, 110**. In one exemplary embodiment, the power supply **116** provides an electric potential across the end walls **108, 110** so that the electrons from one end wall **108** are pulled to the other end wall **110** to create an electron deficiency in one end wall **108** (positively-charged end wall **108**) and an excess in the other end wall **110** (negatively-charged end wall).

[0025] As the particles **104** contact the positively-charged end wall **108**, they lose an electron to become positively charged. Accordingly, the particles **104** repel the positively-charged end wall **108** and each other. At the other end of the housing **102**, as particles contact the negatively-charged end wall **110**, they gain an electron to become negatively charged. Thus, negatively-charged particles **104** repel the end wall **110** and one another. As the particles **104** are agitated and move toward the middle of the housing **102**, the positively-charged particles come into contact with the negatively-charged particles. When two of such types of particles **104** contact one another, the negatively-charged particle donates its excess electron to the positively-charged particle thereby neutralizing both particles. Consequently, both particles become like-charged and repel one another.

[0026] Because numerous particles are included in the plurality of particles **104**, the particles behave like cold, dense plasma when interacting with one another. As the particles **104** repel each other and either end wall **108, 110**, kinematic motion of the particles **104** results. Thus, the particles **104**"self-mix" to further reduce clumping.

[0027] **FIG. 3** illustrates still yet another embodiment. In this exemplary embodiment, the housing **102** is constructed of a conductive material and the particles **104** are made of an insulating material, such as plastic. The power supply **116** is coupled to the housing **102** and configured to positively charge the housing walls **106, 108, 110**. An ultraviolet light source **120** is positioned proximate the housing **102** such as to direct UV photons on to the particles **104**. As the UV photons impinge upon the particles **104**, electrons are removed from the particles **104** and absorbed into the positively-charged housing **102**. Consequently, the plurality of particles **104** becomes positively charged and the particles **104** repel one another. Additionally, the particles **104** repel the positively-charged housing **102**.

[**0028**] Another exemplary embodiment, depicted in **FIG. 4**, employs a high energy light source **121**, a housing **102** constructed of a negatively-charged insulating material, and particles **104** that are initially neutrally or positively charged. During operation, the high-energy light source **121** is aimed at the particles **104**. When the high-energy light impinges on one of the particles **104**, a proton leaves the particle **104** and is absorbed in the negatively-charged insulating material. As a result, the particle **104** becomes negatively charged. As the light hits more particles **104**, more of the particles **104** become negatively charged and, consequently, the like-charged particles **104** repel one another. Because the housing **102** is also like-charged, the particles **104** repel the housing **102** as well.

[**0029**] Turning back to **FIG. 1**, a magnetic field may be applied to the charged components of the system **100** to enhance the damping features of the system **100**. In one exemplary embodiment, the system **100** includes a plurality of particles **104** comprising conductive material and a magnetic field coil **122**. The magnetic field coil **122** includes a wire **124**, power supply **126**, and a shaft **128**. The wire **124** is coupled to the power supply **126** and is coiled around the shaft **128**. As those with skill in the art may appreciate, the power supply **126** coupled to the wire **124** may or may not be the same as the power supply **116** coupled to the housing **102**. In either case, and as is generally known, when current from the power supply **126** flows through the wire **124**, a magnetic field is produced.

[**0030**] When the system **100** vibrates, the application of the produced magnetic field to the system **100** causes the kinetic energy absorbed into the system **100** to dissipate as heat energy. This is due to the Lorentz effect, i.e. the combined effects of the applied magnetic field, the charged system **100**, the induced magnetic field on the charged system **100** and the rate of flow of the particles **104**. For example, the plurality of particles **104** in the system **100** may experience movement caused by mass vibration or the repulsion of the particles **104** from a like-charged particle or wall. The particles **104** may incidentally travel through the applied magnetic field, causing the particles **104** to produce an electrical current therein that creates an equal and opposite induced magnetic field relative to the applied magnetic field. However, because the particles **104** are made of conductive material, each may have an electrical resistance that prevents the electrical current from flowing freely through the particle **104**. This resistance causes the kinetic energy of the particles **104** to convert to and dissipate as heat energy. As a result, particle **104** movement is dampened.

[**0031**] When the walls of the system **100** vibrate, the kinetic energy from the vibration is transferred to the plurality of particles **104** within the housing **102**. As previously mentioned, the absorbed kinetic energy may cause the particles **104** to travel through the applied magnetic field and to dissipate the kinetic energy into heat. Consequently, the system **100** is damped. Moreover, when the mass to be damped experiences vibration, the vibratory motion of the mass is transferred to the system **100** and then to the particles **104**.

[**0032**] The plurality of particles **104** within the system **100** also may be mixed through the use of two magnetic fields. As illustrated in **FIG. 1**, a second magnetic coil **142** may be positioned proximate the first magnetic coil **122** to produce a second applied magnetic field. As known by those with skill in the art, if a moving charge is placed within an applied magnetic field, a force F will be exerted on the charge. When two applied magnetic fields occupy the same space, each applied magnetic field exerts a force upon the charge. The resulting force acting upon the charge is determined by calculating the sum of the two forces. Thus, based on this premise the movement of a charge (e.g., the force exerted on the charge) may be manipulated by varying the components of the two applied magnetic fields or varying the magnetic flux of a given area of either or both of the two applied magnetic fields. These may be achieved by varying the amount of current passing through the magnetic coils **122**, **124**, or by any other known methods.

[**0033**] While at least one exemplary embodiment has been presented in the foregoing detailed description of the invention, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration of the invention in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing an exemplary embodiment of the invention. It being understood that various changes may be made in the function and arrangement of elements described in an exemplary embodiment without departing from the scope of the invention as set forth in the appended claims.

What is claimed is:

1. A mass damper for damping a mass, comprising:

an electrostatically charged housing configured to couple to the mass;

a plurality of electrostatically charged particles disposed within the housing, each particle electrostatically charged with like polarity to that of the electrostatically charged housing.

2. The mass damper of claim 1, further comprising a power source coupled to the housing and configured to supply an electric potential thereto.

3. The mass damper of claim 2, wherein the housing and plurality of particles each comprise a conductive material.

4. The mass damper of claim 1, wherein the housing comprises an insulating material and the plurality of particles comprise radioactive material.

5. The mass damper of claim 4, further comprising an ultraviolet (UV) light source configured to direct UV light on the plurality of particles.

6. The mass damper of claim 5, further comprising a power source coupled to the housing and configured to supply an electric potential thereto.

7. The mass damper of claim 6, wherein the housing comprises a conductive material and the plurality of particles comprises plastic.

8. The mass damper of claim 1, wherein the housing comprises a negatively-charged insulating material, the mass damper further comprising a high-energy light source configured to aim high-energy photons at at least one particle of the plurality of particles to thereby negatively charge the at least one particle.

9. The mass damper of claim 1, further comprising a magnetic field coil configured to provide a magnetic field through the housing.

10. The mass damper of claim 9, further comprising a second magnetic field coil configured to provide a second magnetic field through the housing.

11. The mass damper of claim 1, wherein the housing comprises a tube having first and second ends and endwalls coupled to the first and second ends of the tube, wherein the tube comprises ceramic and the endwalls comprise a metallic material.

12. The mass damper of claim 11, wherein a power source is coupled to the endwalls to induce a positive charge on the first endwall and a negative charge onto the second endwall.

13. A mass damper for damping a mass, comprising:

a housing configured to couple to the mass;

a plurality of particles disposed within the housing; and

a power source coupled to the housing, the power source configured to supply an electric potential thereto and electrostatically charge the housing, whereby when one of the particles of the plurality of particles contacts the housing, the particle is electrostatically charged.

14. The mass damper of claim 13, wherein the housing and plurality of particles each comprise a conductive material.

15. The mass damper of claim 13, wherein the housing comprises an insulating material and the plurality of particles comprise radioactive material.

16. The mass damper of claim 15, further comprising an ultraviolet (UV) light source configured to shine UV light on the plurality of particles.

17. The mass damper of claim 16, further comprising a magnetic field coil configured to provide a magnetic field through the housing.

18. A mass damper for damping a mass, comprising:

a housing comprising negatively-charged non-conductive material, the housing configured to couple to the mass;

a plurality of particles disposed within the housing; and

a high energy light source aimed at the plurality of particles configured to supply high-energy photons to at least one particle of the plurality of particles to thereby charge the particle.

19. The mass damper of claim 18, wherein the particle is negatively charged.

* * * * *